

Introduction to the use of Large-Scale Facilities for Food Science and Technology

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www.europeanspallationsource.se

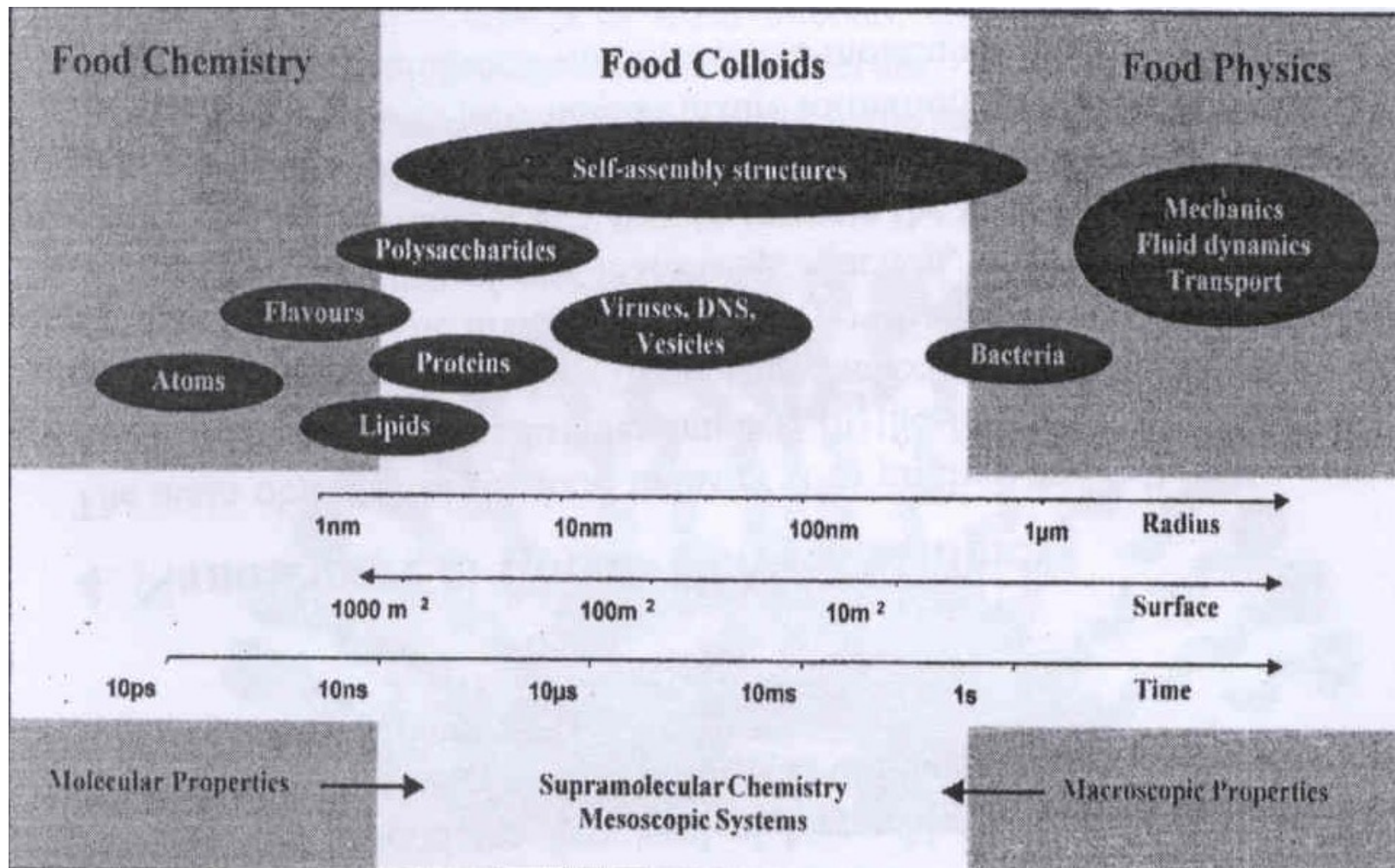
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Foods and Food Products Are Inherently Complex



X-Rays and Neutrons can help!

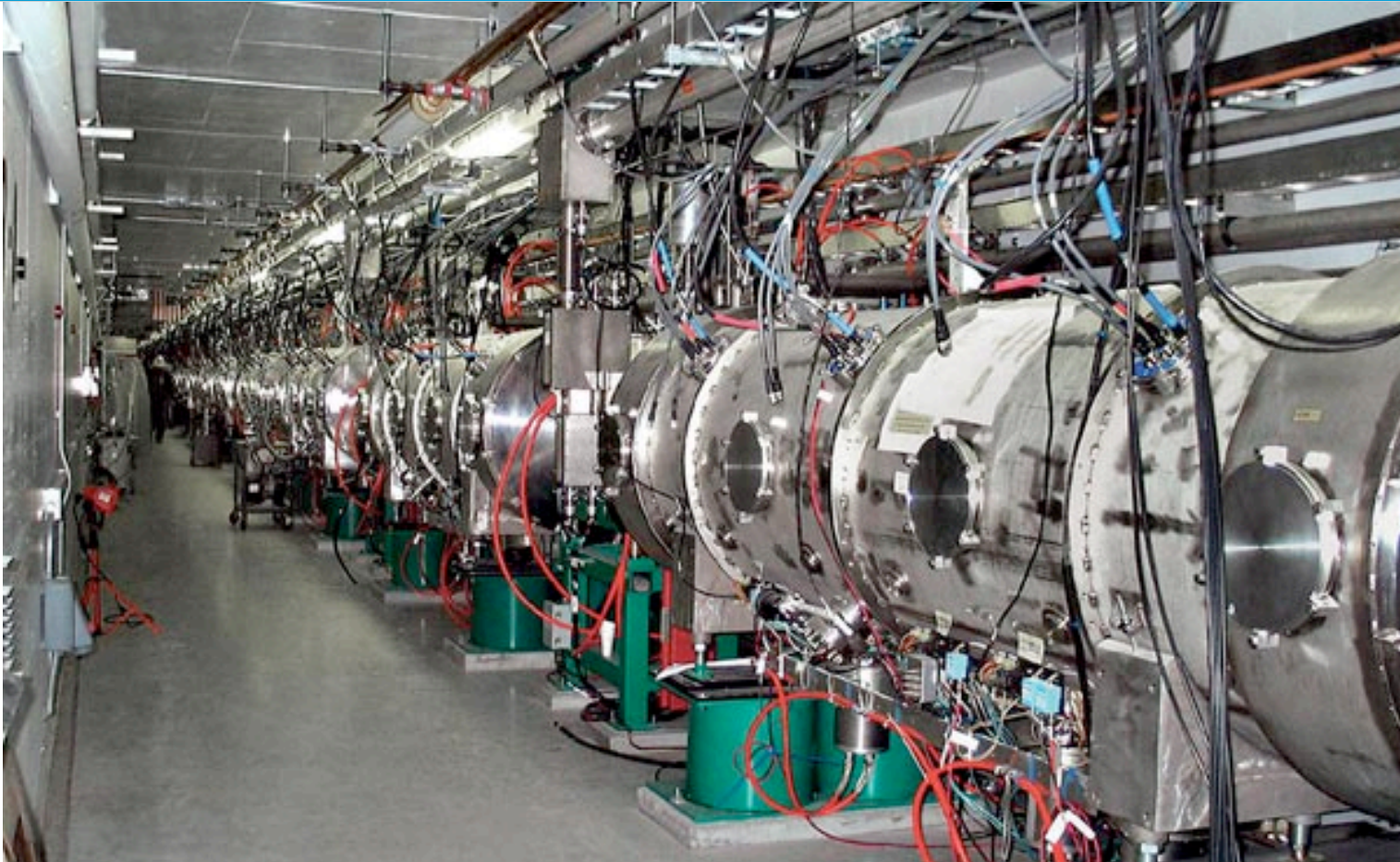
Length and Time Scales in Food Materials



Modern science requires a range of different methods.

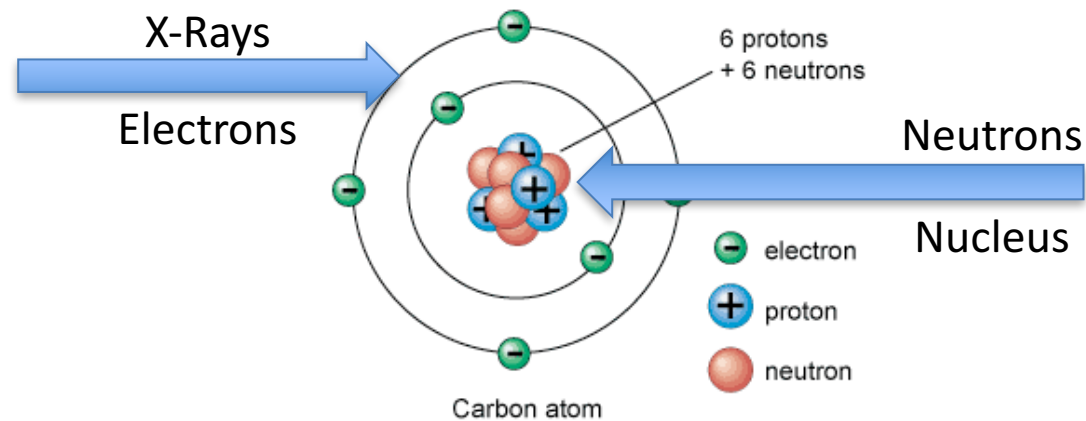


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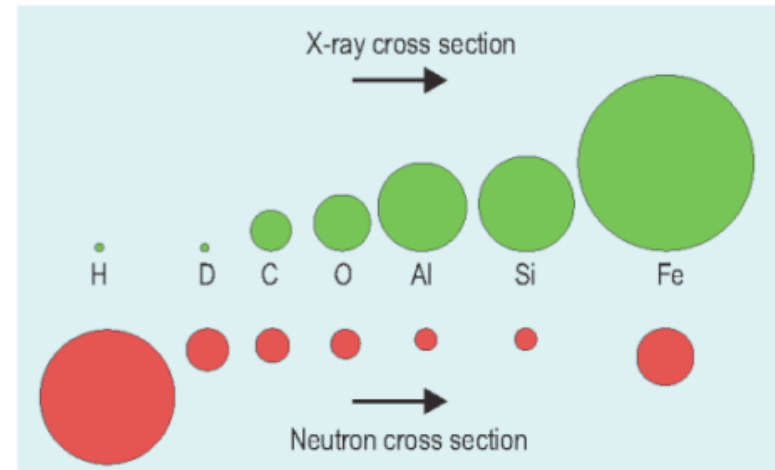
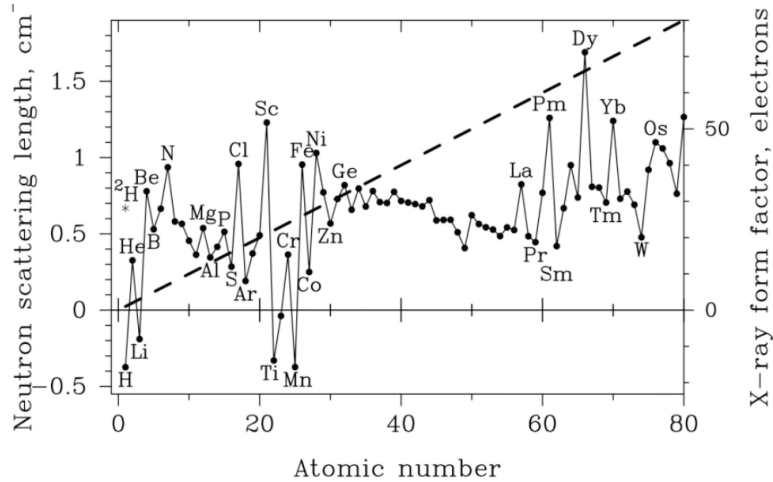
Neutron sources and X-Ray synchrotrons are large-scale facilities for small-scale science.

X-Rays and Neutrons



	X-Ray	Neutron
Mass	None	1.674928×10^{-27} kg (1839 electrons)
Spin	1	1/2
Magnetic Moment	None	$-1.9130427 \mu_n$
Energy	10 eV – 100 keV	0.1 meV – 0.5 eV
Wavelength	0.01 nm to 100 nm	0.01 nm to 3 nm
Source brightness	$10^6 - 10^{20}$ (photons/mm ² /s/mrad/0.1% bandwidth)	$10^{10} - 10^{14}$ (neutrons/cm ² /s/sr/Å)

X-Rays and Neutrons

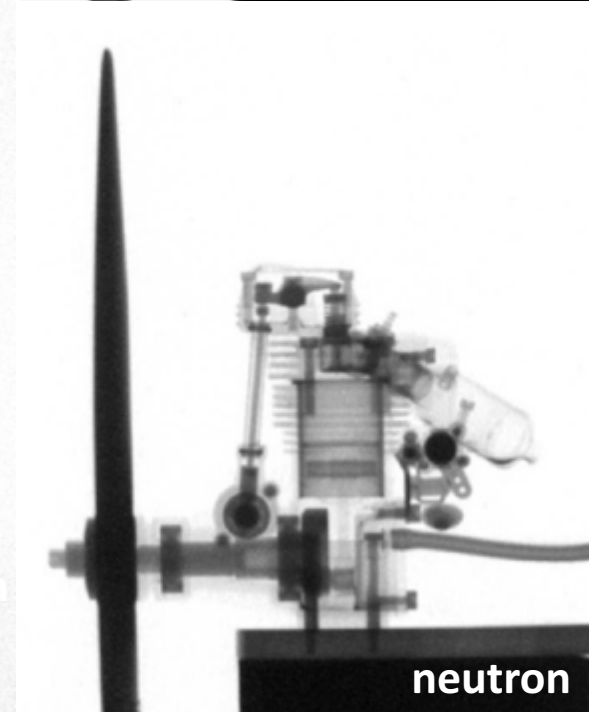
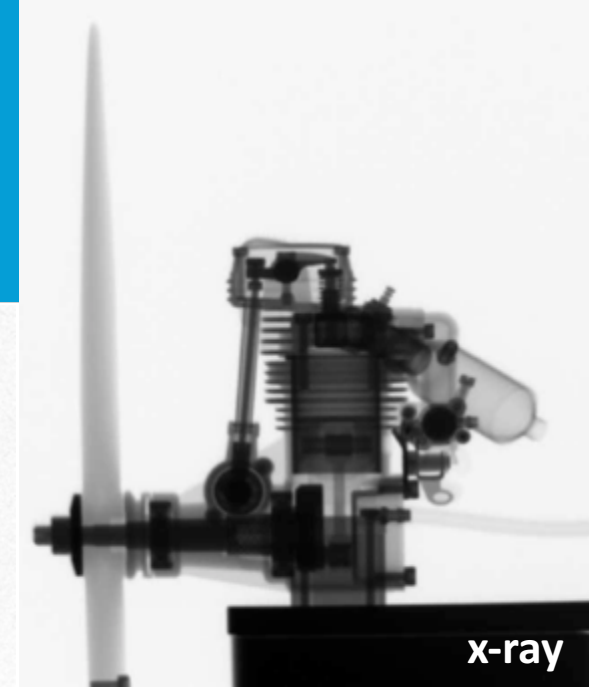
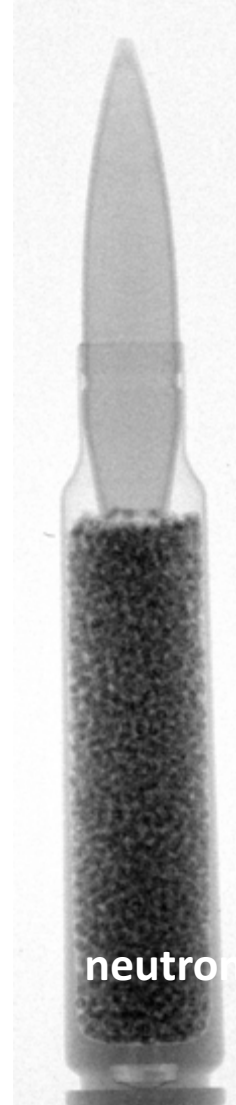


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Neutrons and X-Rays See Things Differently



Courtesy of the NIAG group, PSI, Switzerland.



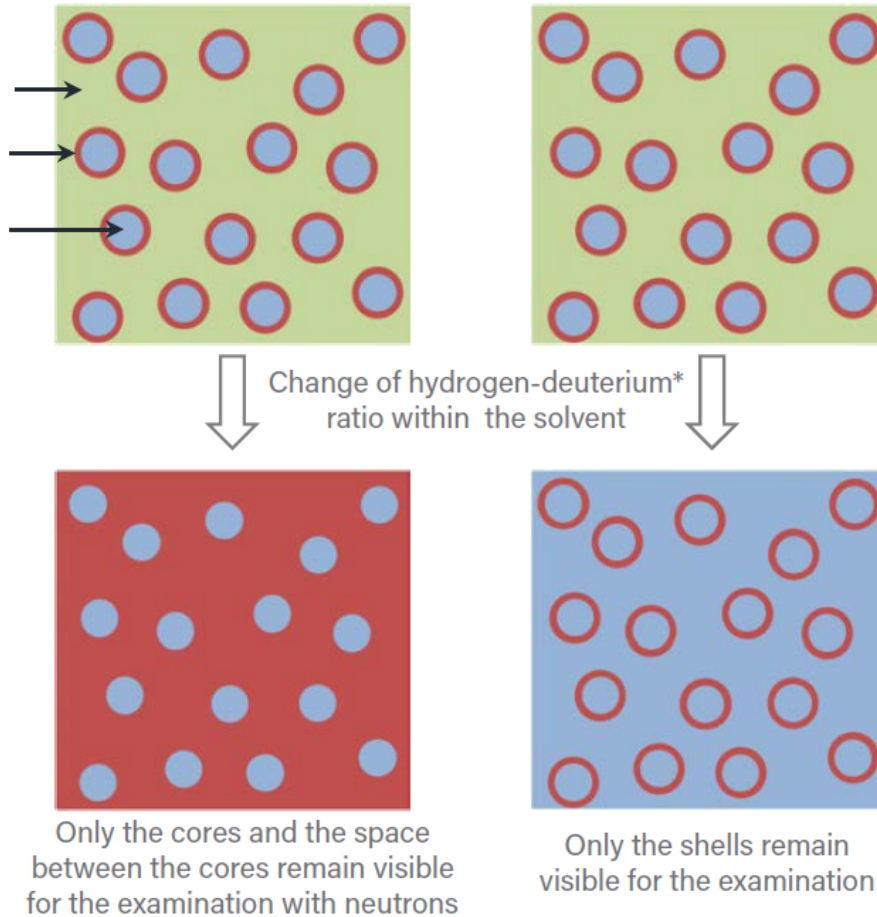
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When the monster came, Lola remained undetected.

Harold, of course, was immediately devoured.

Neutrons and X-Rays See Things Differently



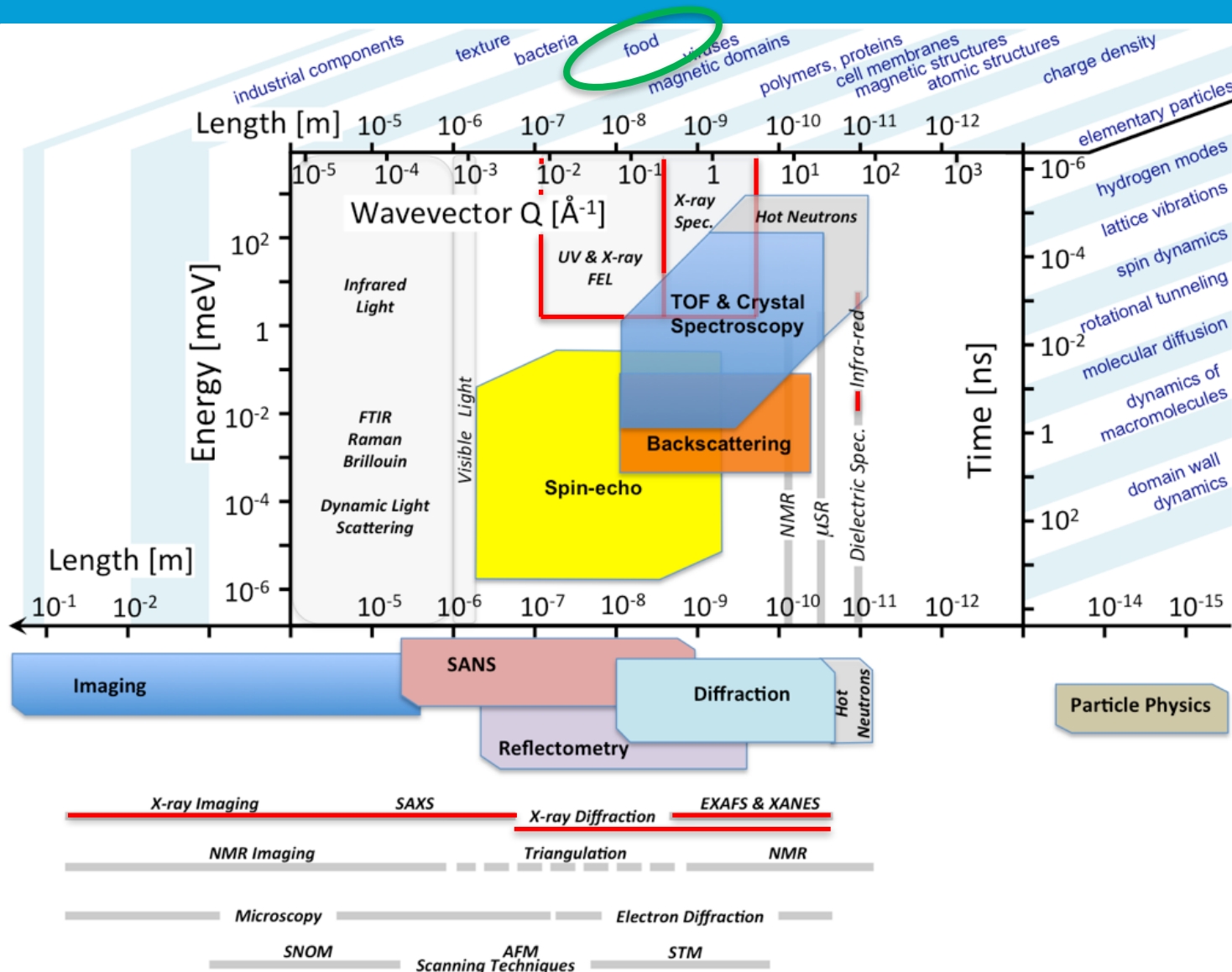
*When the monster came, Lola
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Selective deuteration in
combination with neutrons
lets us investigate selected
parts of complex assemblies.

**Combining X-Ray and
Neutron measurements
provides more information**

Neutron and X-Ray Methods



Improving soft drinks

CO-RO A/S is a large global player in the soft-drink sector. Part of their success is based on an cloudifier that is used to give their product a long shelf life and a desirable visual appearance.

Using ultra small-angle X-ray scattering (USAXS) and small-angle neutron scattering (SANS), the behavior of this ingredient has been characterized, giving insight into its mode of action.

This is the start of a process of further product development, enhancing product stability and compatibility with the natural fruit ingredients.

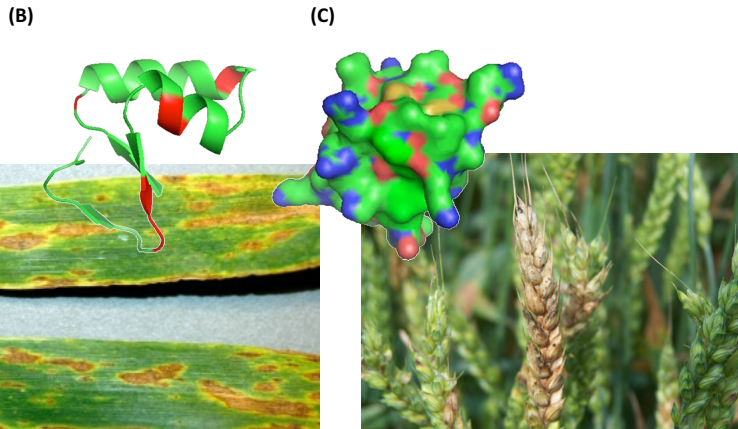
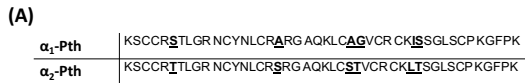


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Plant antimicrobial & antifungal proteins

α -purothionins

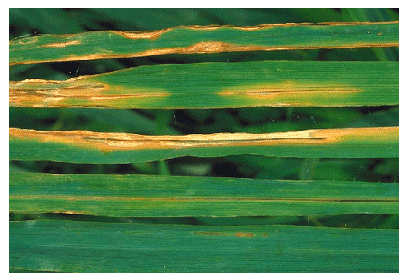


Tan spot (*Pyrenophora tritici-repentis*)

Glume Blotch (*Stagonospora nodorum*)

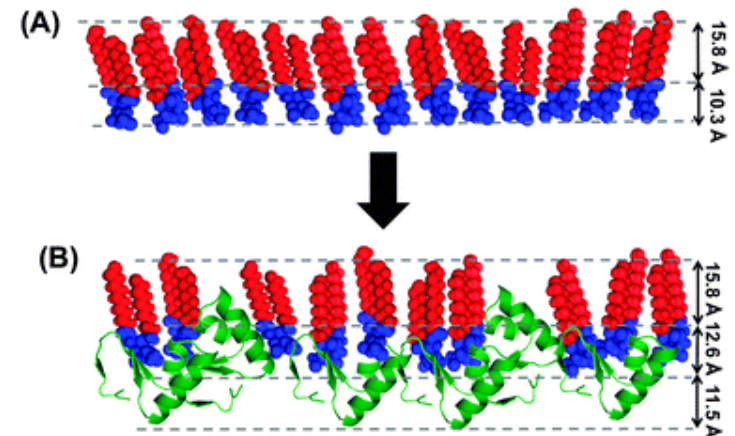


Common Smudge (*Cochliobolus sativus*)



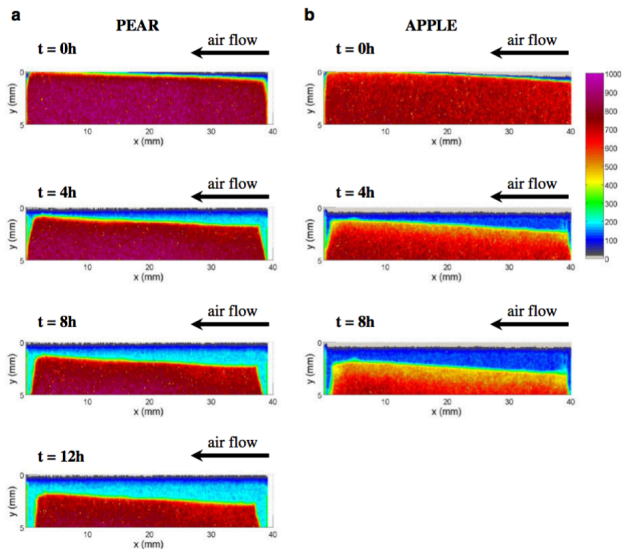
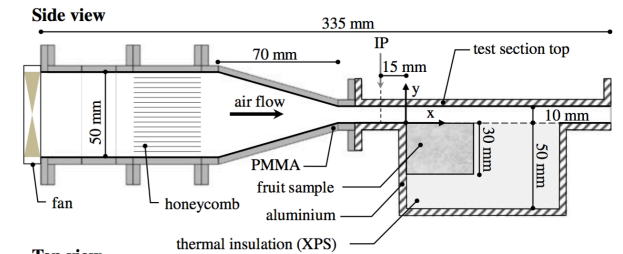
Stripe blight (*Pseudomonas syringie*)

Neutron reflectometry used to determine how plant defence proteins from common wheat interact with cell membranes.

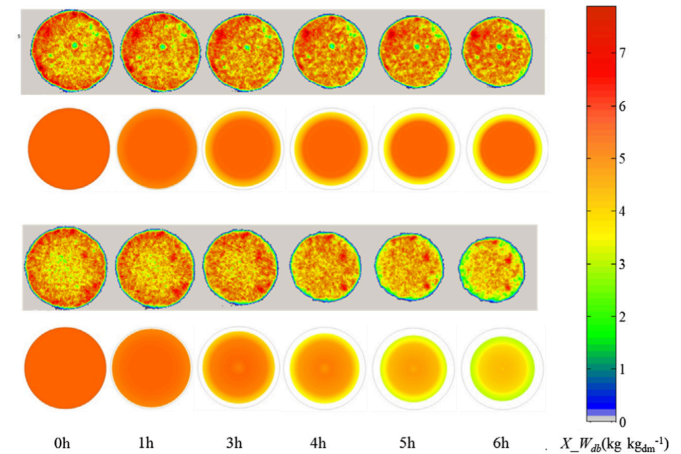
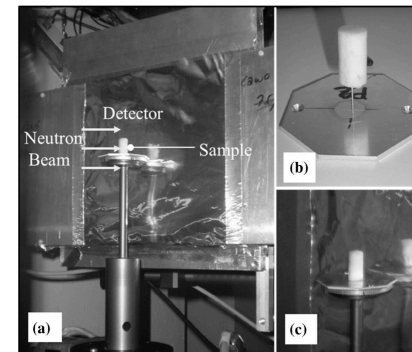


Drying of fruit

In-Situ drying in wind tunnel using neutron imaging to quantitatively determine water loss and water loss profile



Neutron tomography of dehydration of apple used to examine water loss and validate numerical simulations of drying



Investigating leaves is easy, investigating roots is hard.

Investigating root systems

- Understand processes *in situ*.
- Growth, damage, hydraulic failure
- Temporal & spatial dynamics of water within soil and plant
- Soil-microbe-root rhizosphere dynamics
- Improve mechanistic models of root water & nutrient uptake

Limitations of traditional techniques

- Indirect measurements.
- Must use large roots - small roots too fragile.
- Often bulk soil & root measurements
- Measurements invasive, results may be confounding.
- Destructive sampling only gives point measurement.



Root distribution, competition, symbiosis



Switchgrass & maize seedlings

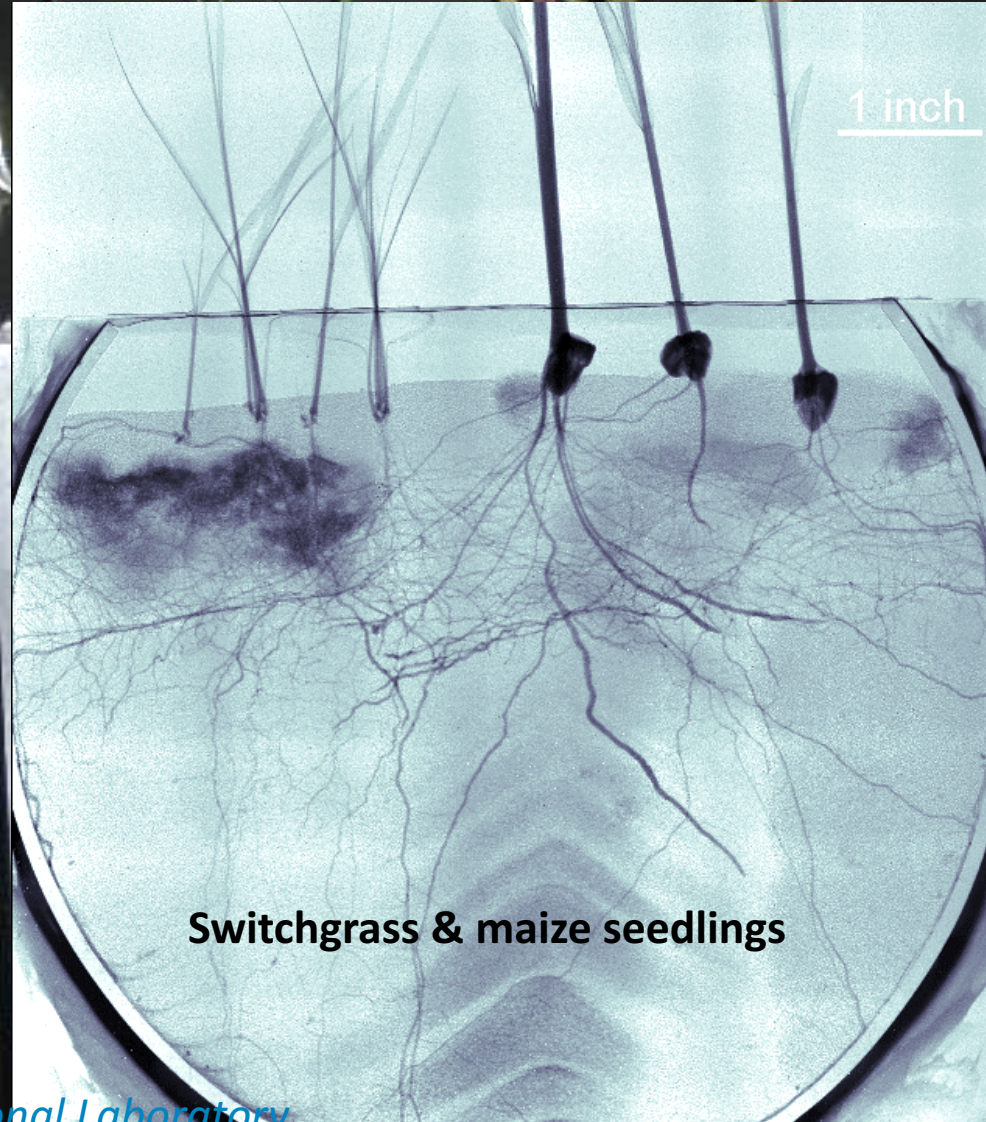
Courtesy of Jeffrey Warren, Oak Ridge National Laboratory

Root distribution, competition, symbiosis

Coarse and fine root morphology and distribution readily visible.

Fungal hyphal mass visible near roots of switchgrass, revealing substantial hydration of the rhizosphere.

Triangular pattern in soil indicates varying water content & porosity due to separation of particle sizes as chamber was filled with sand.



Barley Seed Germination

- High quality malt required for beer and whiskey production
- Malt quality depends on:
 - Water uptake during germination
 - Enzymatic degradation of endosperm
- In-situ x-ray imaging of germination

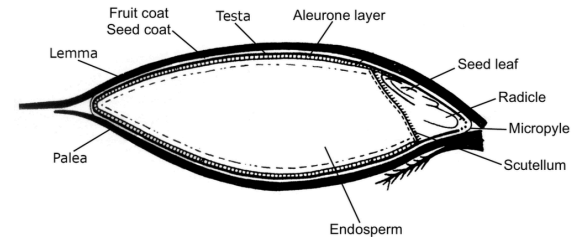


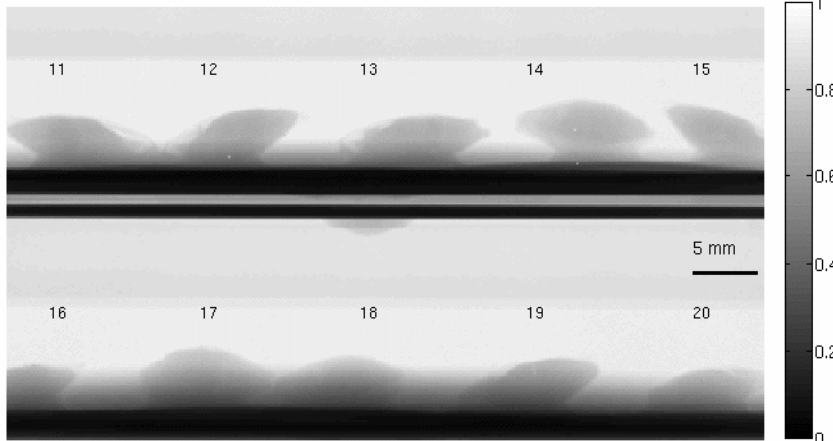
Figure 2. Schematic structure of a barley seed (adapted from Briggs (1998))



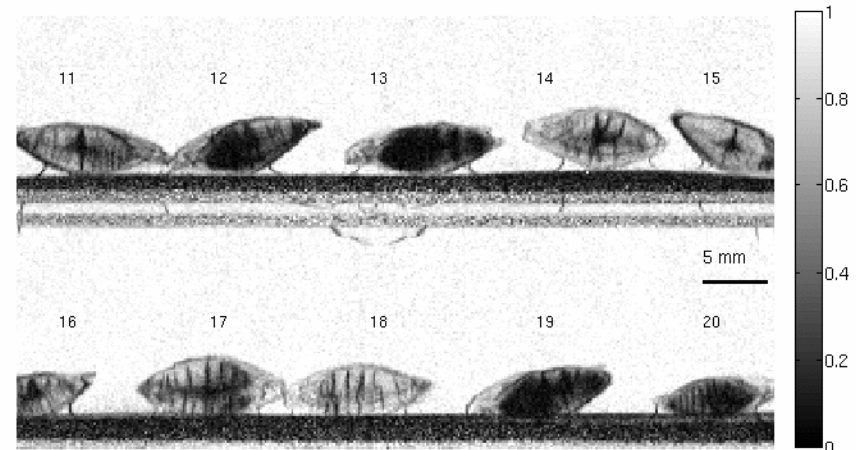
Figure 3. Barley seed with exposed endosperm. Source: GoodMills Innovation GmbH.

Barley time 0 h

Transmission



Dark-field



The ecosystem: ESS, MAX IV and Science Village Scandinavia



SCIENTIFIC COLLABORATIONS

- Life science support lab
- Grants (Interreg program)
- Conferences
- Summer schools
- LINXS (LU)
- Support labs
- Industrial liaison
- Nano safety center (prestudy)

FACILITY COLLABORATION

- Guest house (2017 temp)
- Exhibition (now)
- Envisaging joint user meetings
- Envisaging joint access modes
- Technical collaborations



MAX IV
World-leading
synchrotron, opened
in 2016.

**Science Village
Scandinavia, SVS**
Planned for 2019.

ESS
First users 2023

Questions?



Neutrons & Food

Sydney, Australia

October 16th – 19th 2018
Darling Harbour, Sydney, Australia

